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SIEMENS
WELTVERKEHRS
TECHNIK

LEVEL METER

-100 to + 30 dbm

with

Automatic Tuning for Selective Measurements

0.3 to 1200 kc/s · Type Rel 3 D 332s, s2

Description and Instructions for Use

F 208

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SIEMENS & HALSKE AKTIENGESELLSCHAFT

WERNERWERK FÜR WEITVERKEHRS- UND KABELTECHNIK · MÜNCHEN

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I. APPLICATION

In conjunction with the level oscillator Type Rel 3 W 29s or s2 this level meter allows all important measurements on lines and radio paths with multichannel carrier operation and on their components within a frequency range of 0.3 (2) to 1220 kc/s. Level oscillator and level meter thus combine to a complete carrier-frequency measuring setup that qualifies for measurements in stations, laboratories, and test rooms equally well as for measurements on the route.

Measurements are possible not alone of power and voltage, but also of impedance, return loss, and balance-to-unbalance ratio; all these can be made on narrow-band basis, with the aid of the built-in heterodyning converter, as well as on wideband basis. As a narrow-band level meter of high sensitivity and low residual distortion the instrument allows moreover measurements of crosstalk attenuation up to 130 db and distortion attenuation[+], from which the distortion factor can also be determined.

A particular advantage of the instrument consists in the fact that the heterodyning voltage can be taken from the level oscillator when it is set up at the same place so that selective measurements are possible without any need for separate tuning of the level meter.

[+] Distortion attenuation" (Klirrdämpfung) is the reciprocal distortion factor, expressed as a logarithm.

Measurements are possible of power levels, as referred to 1 mw into 75, 135 (or 140) Ω and 600 Ω, between -100 and +30 dbm selectively from 2 kc/s onward, and between -50 and +30 dbm on wideband basis from 300 c/s onward. The input impedance can be switched to "Z" or "High". In the 600-Ω positions the level reading is at the same time also the voltage level (as referred to 0.775 v).

The frequency range comprises all two-wire and four-wire carrier systems for open-wire lines and balanced cable lines as customary at present, as well as the CCITT basic group (60 to 108 kc/s) and CCITT basic supergroup (312 to 552 kc/s). For general studies and future development the further frequency band is also available up to 1220 kc/s, as well as the VF band of the voice channels (300 to 3400 c/s, wideband) below the former.

Connected as narrow-band (channel) level meter the device is so selective that any level sent in a carrier-derived voice channel can be measured in its carrier position without the result being affected by telephone traffic on adjacent channels.

Particular emphasis has also been placed on low residual distortion of the front-end circuit so that measurements of the transmitting level in two-wire systems will not affect the receiving level of the distant direction which is up to 70 db lower.

For fault location on carrier systems taken out of service, and for measurements with level oscillator and level meter set up at different locations, the level meter can be switched to wideband operation. Quite generally the level meter is useful as narrow-band and wideband detector for many other measuring problems of communications, e.g. bridge measurements, frequency analysis, etc.

The level measuring setup can finally be simply expanded to a sweep-frequency measuring setup by the addiition of the sweep drive Type Rel 3 W 914a or b and the level tracing receiver Type Rel 3 K 29s, where the measuring result is traced out as a continuous function of frequency, but with all advantages of selective measurements retained.

The operational voltages are taken from AC mains of 110, 220 v (120, 240 v) via the built-in power supply unit. Model Rel 3 D 332s2 can be reconnected for AC mains of 110, 130, 220, or 240 v.

II. ELECTRICAL DATA

Frequency range

with wideband measurements . . . . . 0.3 to 1220 kc/s

with narrow-band measurements . . . . . 2 to 620 and 600 to 1220 kc/s

Input

Input impedance

with f_m < 600 kc/s . . . . . approx. > 5 kΩ

with $f_m \geq$ 600 kc/s . . . . . approx. > 3 kΩ

can be switched to . . . . . 75, 135, or 140 Ω and 600 Ω

Balance-to-unbalance ratio for f_m < 900 kc/s . . . . . > 48 db

for $f_m \geq$ 900 kc/s . . . . . > 40 db

Linearity of the front-end circuit:

Distortion attenuation+ (a_{k2}, a_{k3}), with parallel connection of a resistor between 75 and 600 Ω to the high input impedance . . . . . > 95 db

for f_m > 12 kc/s and 75 Ω . . . . . > 120 db

Wideband level measurements

Level range for full-scale deflection

in 7 steps of 10 db . . . . . from -40 to +30 dbm

Minimum readable level . . . . . -65 dbm

Level error at the center of the frequency range, as referred to full-scale deflection . . . . . ±0.2 db

Frequency response of the level measurement

for f_m < 900 kc/s . . . . . ±0.2 db

for $f_m \geq$ 900 kc/s . . . . . ±0.3 db

Change of the reading with mains voltage variations of ±10 % . . . . . ±0.1 db

Narrow-band level measurements

Level range for full-scale deflection

in 12 steps of 10 db . . . . . from -90 to +30 dbm

Minimum readable level . . . . . -115 dbm

Level error at the center of the frequency range, as referred to full-scale deflection . . . . . ±0.2 db

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+ See footnote on p. 2

Change of the reading with mains voltage variations of ±10 % . . . . . ±0.2 db

Frequency response of the level measurement

for f_m < 900 kc/s . . . . . ±0.2 db

for $f_m \geq$ 900 kc/s . . . . . ±0.3 db

in the range +30 dbm and with one side of the circuit grounded, for f_m > 900 kc/s . . . . . ±0.5 db

Intermediate frequency f_{z1} . . . . . 1304 kc/s

Intermediate frequency f_{z2} (available at output jacks) . . . . . 2 kc/s

Heterodyning voltage taken from built-in local oscillator or from the associated level oscillator

Frequency f_1 . . . . . 1306 to 1924 kc/s, 1904 to 2524 kc/s

Frequency calibrating error . . . . . ±0.2 % ±200 c/s

Voltage required from the level oscillator (automatic tuning system) . . . . . approx. 1.2 v across 75 Ω

Heterodyning frequency f_2 . . . . . 1302 kc/s

Attenuation distortion within the pass band f_m ±40 c/s . . . . . ±0.2 db

Stop-band attenuation at ±300 c/s from f_m . . . . . > 60 db

Image-frequency rejection (at f_m +4 kc/s) . . . . . > 60 db

Distortion attenuation measurements

Residual distortion attenuation . . . . . > 70 db

Impedance measurements

Impedance range . . . . . 50 to 3000 Ω

Impedance error . . . . . approx. ±10 %
(with capacitive impedances this holds for C > 200 µµf only)

Measurements of return loss and balance-to-unbalance ratio

Measuring range . . . . . up to 40 db

Measuring error

for unknown (Z) and standard (N) between about 60 and 1200 Ω . . . . . approx. ±1 db

Power supply

Model s . . . . . 110/220 (120/240) v ±10 %; 40 to 60 c/s; approx. 80 va

Model s2 . . . . . 110, 130, 220, 240 v ±10 %; 40 to 60 c/s; approx. 80 va

III. FUNCTION AND LAYOUT

The level meter consists of a wideband preamplifier, a wideband level meter circuit, and a heterodyning converter which integrates with the former to a selective level meter, as well as of a measuring field allowing reconnection for the various measuring functions and sensitivities, and of a power supply unit.

1. Preamplifier (Figs. 4 and 11)

The unkown voltage is applied to the preamplifier via the measuring field (see Sec.III,4; p.9). It consists of two low-noise double triodes (CCa, tubes 1a and 1b) of which the former is cascode-connected for pentode action. In the second stage the two triode sections are so connected in series that a low output impedance results. By degenerative coupling switched with S1 the gain is so modified that the power level (as referred to 1 mw) can be read direct on the meter scale for the impedance values 75 Ω, 135 or 140 Ω and 600 Ω.

2. Wideband level meter

In the positions "Wideband" of the switches S2 and S3 the output of the preamplifier reaches the following four-stage wideband amplifier with tubes 6, 7, 8, and 9 (4 - C3g). Two degenerative paths linearize it so efficiently that its gain is constant throughout the frequency range of 0.3 to 1220 kc/s and also remains widely independent of variations of the power supply voltage and spread in tube data. With the potentiometer P1 (Calibrating ▼ I) the output voltage can be adjusted to the nominal value by variation of the degenerative coupling (see Sec.III. 4.b, p. 9). A voltage doubler circuit with crystal diodes Gl 6, Gl 7 and a capacitor C61 rectifies the amplified signal. The panel meter J reads the RMS voltage of the signal under test. Its scale extends from -25 to +2 dbm; below it, a scale from 300 to 50 Ω is arranged for impedance measurements. With S5 the detector circuit can be switched our of circuit and the amplified AC voltage applied to output jacks instead.

3. Heterodyning converter

For selective measurements a heterodyning converter is connected between the preamplifier (tubes 1a, 1b) and the wideband level meter circuit. In the ring modulator (tubes 2 and 3; 1 - E91AA) the unknown sig-

nal of frequency f_m is heterodyned with an AC voltage of the frequency $f_1 = f_m + 1304$ (all values in kc/s). This heterodyning voltage is obtained either from the associated level oscillator Type Rel 3 W 29s or s2 via a coaxial cord (for automatic tuning of the level meter), or from the built-in local oscillator unit G1 with tube 10 (C3m) and tuned circuit Ü5, C3, K1 (manual tuning). For this purpose its frequency can be controlled with a variable capacitor K1 continuously and with S4 in two steps (1306 to 1924 kc/s and 1904 to 2524 kc/s). The two associated scales are graduated in input frequencies f_m and their developed length is 40 in. (1 m) so that accurate readings are possible. A lamp indicates the band activated at the time. The trimmer K2 (corr. ≈) adds capacitance to the tuned circuit for correcting the frequency of the oscillator unit G1; the frequency of the calibrating generator G3 (8 kc/s) is used for reference.

A crystal filter following the ring modulator selects from the mixing products the signal of difference frequency 1304 kc/s. It passes the two following amplifier stages (tubes 4 and 5; C3g) and via a transformer Ü2, whose primary is resonated at 1304 kc/s, it reaches an additional modulator with crystal diodes G1 2 to G1 5 for modulation with a voltage of constant frequency. For this purpose the oscillator unit G2 (tube 11; C3m) supplies a signal of the frequency $f_2 = 1302$ kc/s which is stabilized in frequency by a crystal and in amplitude by a regulating lamp.

From the resultant mixing products a resonant circuit (Ü3, C71) selects the difference frequency of 2 kc/s. This signal is once more applied to the grid of tube 4 for renewed amplification in both stages. The amplifier stages (tubes 4 and 5) are thus turned to double use in a reflex circuit.

The audio-frequency output voltage (2 kc/s) of this circuit passes via a 2-kc/s filter, a voltage divider R1, R2, R3 and switches S2, S3 to the input of the wideband amplifier.

In all "selective" positions of the switches S2 and S3 the network C1, C2, R4 is connected in parallel to its output via the rectifier G1 which acts as electric valve; this network attenuates all interfering frequencies above 2 kc/s.

In the most sensitive channel level range the meter receives a small opposing positive voltage from the cathode of tube 9, for compensation of the mean noise voltage.

The calibrating oscillator G3 (tube 12; C3m) supplies a voltage of 8 kc/s for calibrating the wideband amplifier and the heterodyning converter and integrates mechanically with the oscillator unit G2. For amplitude stabilization its feedback path includes a bridge circuit with regulating lamp so that the calibrating voltage is widely independent of the tube data and voltage variations of the power supply.

4. Measuring field

a. General

The preamplifier is preceded by the transformer Ü1 so that for frequencies up to 600 kc/s a balanced input impedance of more than 5 kΩ is effective, without relation to ground; at higher frequencies the impedance still remains above 3 kΩ. With the switch S1 the input impedance can be reduced to the respective impedance value by the parallel connection of resistors, apart from adapting the sensitivity corresponding to a reference power of 1 mw into 75, 135 (140) or 600 Ω (see Sec. III.1).

The function switch S2 serves for setting the various calibrating and measuring circuits for which the measuring field contains the components required in addition to the tube circuits.

The level range switch S3, Type Rel 35 D 130d, has extra positions for measurements of wideband and channel levels and for impedances. It switches the voltage dividers with resistors R1 to R11 after the input transformer Ü1 and (for the highest sensitivity steps of the selective level meter) the voltage divider at the output of the heterodyning converter (R1, R2, R3).

With all measuring connections wideband and selective measurements are equally possible. With use of the automatic tuning system, selective measurements are as simple and fast as wideband measurements.

b. Calibrating circuit (Fig.3). In the calibrating positions of switch S2 the jacks "Level" are disconnected from the level meter circuit and a calibrating signal delivered by the 8-kc/s calibrating generator (G3) is connected to the grid of tube 1 instead. (The relays B and C in the preamplifier are restored, as in the connection for Z = 600 Ω). In the calibrating position "▼I" the output AC voltage of the preamplifier appears at the wideband amplifier so that its output can be adjusted to the nominal voltage with the potentiometer P1 (calibrating "▼I").

For calibrating the selective level meter, with switch S2 in the calibrating position "▼II", the heterodyning converter is interposed between the preamplifier and the wideband level meter. Corresponding to the higher sensitivity the calibrating voltage at the input of the preamplifier is reduced. The gain of the heterodyning converter can thus be adjusted (with the potentiometer P2) after tuning the oscillator unit G1 to the calibrating frequency.

c. Level measuring circuit (Fig. 4). In the positions "Wideband Level" and "Selective Level" of switch S2 the input jacks are connected to the input of the preamplifier via the transformer Ü1 and the voltage divider S3. With wideband measurements the preamplifier feeds directly into the wideband amplifier. With S3 the measuring range can be set between -40 and +30 dbm (full-scale values). For selective level measurements the switch S2 connects the heterodyning converter between preamplifier and wideband level meter. The level setting range for full-scale deflection extends from -90 to +30 dbm for all three impedance values.

d. Impedance measuring circuit (Fig. 5). The impedance under test may be real or complex, grounded or floating. The measuring power comes from a level oscillator, e.g. Type Rel 3 W 29s with a source impedance of almost zero; via the input jacks "G" this source is applied to a transformer Ü2. Its secondary is connected in series with the specimen applied to the jacks "X" and precision resistors R4, R5. This connection is established in the two positions "Impedance" ("Wideband" or "Selective") of the function switch S2.

With constant generator voltage the magnitude of the unknown impedance determines the current and thus also the voltage drop across precision resistances R4, R5 that are small with respect to the unknown impedance. Via a current transformer Ü3 this voltage drop is applied to the input of the level meter circuit in its wideband or selective setting. The magnitude of the impedance can be read directly on the meter scale graduated in ohms; with S3 the sensitivity of the level meter can be switched for measuring multipliers x1, x2, or x10. The ohm scale holds for the positions "600 Ω" of S1 and a transmitting voltage level (as referred to 0.775 v) of +17 db with wideband, and of -10 db with selective, connection of the level meter circuit.

e. Measuring circuit for balance-to-unbalance ratios (Fig. 6)

The bridge circuit for measuring the balance-to-unbalance ratio (with respect to ground) of a wire pair, equipment input or output includes the ground impedances of the specimen (W1 (AD) and W2 (CD)) and the winding halves of a differential transformer Ü4. The generator voltage appears at the diagonal AC; the level meter measures the bridge unbalance voltage between ground (D) and center-tap of the transformer (B). The difference between the transmitting voltage level and the level indicated by the level meter gives the bridge loss; it consists of the basic loss (17 db) and the balance-to-unbalance ratio ($20 \log_{10} \frac{W1+W2}{W1-W2}$ in decibel).

In the case of a transmitting voltage level of +17 db and a source impedance of almost zero the measuring procedure becomes particularly simple, since the balance-to-unbalance ratio equals in magnitude the level meter reading, if switch S1 is in one of its positions "Z = 600 Ω".

f. Measuring circuit for return loss (Fig. 7). For the measurement a similar bridge circuit is employed. The bridge arms are the two winding halves of the transformer also used in measuring the balance-to-unbalance ratio (AB, BC), the line of impedance Z (CD) applied to the unknown jacks X, and the complex impedance N (DA) connected to the jacks "Level, Balancing Network".

The return loss in decibel is defined by the term $20 \log_{10} \frac{Z+N}{Z-N}$. It equals the difference between the measured transmitting and receiving voltage levels, less the basic bridge loss (17 db again). With a transmitting voltage level of +17 db and a source impedance of almost zero the voltage level appearing across the specimen (Z or N) is of the order of 0 db; besides, the return loss just equals the read value, if switch S1 is in the position Z = "600 Ω ▼ high impedance".

4. Power supply unit

With the relocate fuse[+] the power transformer can be conveniently reconnected from 220-v to 110-v operation or, after resoldering certain links on its terminal strip, from 240-v to 120-v operation; the on/off power

[+] Model Rel 3 P 443s2 is adjusted to the respective mains voltage 110, 130, 220, 240 v with a switch inside the set.

switch S6 connects it to the mains. The power supply unit provides all voltages required for operation, viz. an anode DC voltage and a screen grid voltage, stabilized by two neon tubes (St1 and 2), of about 200 v DC each, as well as heater voltages of 20 v AC and 6.3 v AC; also supplied is DC for the relays.

5. Layout

The chassis of the level meter is accommodated in a casing of standardized size A9 as per DIN 41490; for better cooling it is perforated at top and rear. The front (Figs. 1 and 8) carries the switches required for operation, the panel meter, and the connecting jacks as well as fuse, power switch and power cord.

After removal of the chassis from the casing, the electron and stabilizer tubes are accessible from the rear. Fig. 2 shows a rear view of the chassis.

IV. INSTRUCTIONS FOR USE

1. Preparation and layout of the measuring setup

The electron and stabilizer tubes are inserted in the factory. The device is supplied in the condition for 220-v AC mains. For use in 110-v mains unscrew the fine fuse, withdraw the covering collar of the relocate fuse and reinsert it so that the numeral 110 appears in the small aperture. By the relocation of soldered links on the power transformer according to Fig. 11 the device can also be reconnected for the two options 240/120 v. If such reconnection has been made already in the factory, the figures appearing in the small window of the relocate fuse are 240 and 120 v. - With the mains voltage adjuster switch (above the meter, can be controlled from above on the withdrawn chassis) model s2 can be set for mains voltages of 110, 130, 220, or 240 v. The 1-a fuse can be used for any of these voltages.

The level meter Type Rel 3 D 332s or s2 integrates with the level oscillator Type Rel 3 W 29s or s2 to a setup for all important measurements at frequencies up to 1220 kc/s. These instruments contain all facilities for wideband and selective measurements of level, loss, and crosstalk attenuation, impedance magnitude, distortion attenuation and balance-to-unbalance ratio; only measurements of return loss require in the carrier-frequency range an extra decade capacitor, e.g. Type Rel 3 B 51, and decade resistor, e.g. Type Rel 3 B 41, and measurements in the audio range require a variable balancing network, e.g. Type Rel 3 L 311, or balancing-network synthesizer, e.g. Type Rel 3 L 21.

Fig. 9 shows the measuring setup and its expansion to a sweep-frequency setup for selective measurements by addition of the level tracing receiver Type Rel 3 K 29s and sweep drive Type Rel 3 W 914a,b with required connecting cords (see Sec. IV.9, p. 21 and associated individual descriptions). Fig.10 shows an example of level measurements along a carrier-frequency route (V120, one direction).

With the measurements use shielded cords for all connections, e.g. Type Rel ltg 546. If the specimen has no corresponding jacks, one may use the cords Type Rel ltg 703 which terminate at one end into three single banana plugs. Level jacks in the audio range have no shielding terminal as a rule; for such applications the connecting cords Type Rel ltg 548 are suitable.

In the case of specimens of high attenuation, above all if one side is grounded, keep the cords of the measuring setup as short as possible. For the jacks of the automatic tuning system use always the coaxial cord Type Rel ltg 533; for selective measurements without automatic tuning it must always be unplugged on the level meter.

Before taking any further steps apply a ground to the device. Appliances with three-wire safety plugs are automatically grounded via the ground-continuity contact, if the latter is extended from the power outlet via a not current-carrying line to a ground free of interfering potentials. The shields of the connected lines carry always the chassis potential of the measuring instruments; if they are grounded also at the specimen, leave the grounding terminal of the device unconnected, to avoid multiple grounding. Before the grounding condition of the set extended via a line shield is interrupted, however, establish another ground, e.g. via the grounding post, or disconnect the set from the mains altogether, for compliance with the safety regulations of the VDE (Association of German Electrical Engineers).

Connect the level meter to the AC mains and turn it on with S6; the indicating lamp beside the power switch is now lighted. About 15 minutes later the level meter is ready for use.

2. Calibration

a. of the wideband level meter

Settings: S1 at Cal. "▼", S2 at calibrating "▼I", S3 preferably set on a level range suitable for the future measurement or on one of the least sensitive ones so that the instrument is not exposed to a surge as the transfer to measuring (S2) is effected. The positions of S4 and K1 are arbitrary.

Alignment: With P1 calibrating "▼I" to the red mark "▼" of the meter.

b. of the channel level meter

The procedure "Cal.I" must be terminated.

Settings: Same as under (a), but switch S2 at calibrating "▼II", S4 at "2 to 620 kc/s".

Frequency alignment: Adjust K1 for maximum meter deflection. This setting shall be in the red sector at 8 kc/s. If the frequency is also to be determined in this tuning procedure (e.g. with measurements of distortion attenuation) operate K1 to "▼" (at the 8-kc/s mark) and adjust the control K2 "cor. ≋" für maximum meter deflection.

Amplitude adjustment: With P2 calibrating "▼II" bring the meter deflection to the red mark "▼".

In operation with automatic tuning system it is necessary to offset the relative frequency error between level oscillator and crystal filter of the channel level meter. For this purpose connect preferably the level oscillator output to the level meter input and set the oscillator for a middle frequency, e.g. 300 kc/s, with zero level and a source impedance of almost zero. In the level meter operate S1 to Z = "600 Ω, High-Imp.▼" and S2 to "Level Sel.", S3 to "Lev.Sel. 0 dbm". In the level oscillator tune K1 "Freq. Contr.Fine" for maximum deflection of the panel meter.

For accurate relative measurements this connection can also be used for equalizing the calibrating errors of level oscillator and level meter which in the most adverse case may add up to 0.4 db. For this purpose operate in the level meter the control S2 to "Wideband", S3 to "Wideband 0 dbm" and adjust the calibrating control P1 "▼I" accurately for a deflection of 0 dbm, after adjusting also the level oscillator accurately for a transmitting level of 0 db.

3. Level measurements (Figs. 4 and 9)

Measurements of level, attenuation, and gain on inactive devices and line sections are possible on wideband basis. Since the level meter indication is virtually flat, wideband measurements are considerably simpler than selective measurements in cases when automatic tuning cannot be employed (e.g. with measurements along a transmission path). Besides on wideband basis, the voice frequency channels can be measured from 300 c/s onward.

With selective level measurements the pass band extends ±40 c/s about the frequency set while other signals present at the point of measurement are attenuated more than 60 db provided they are at least 300 c/s away from the measuring frequency. In carrier systems level tones fed

into a VF channel can tus be retrieved for measurement at the various points along the transmission path in their respective frequency positions without any need for inactivating adjacent channels. Successive measurements on a number of channels distributed over the transmitted frequency band thus yield a general picture of the frequency response of the carrier-frequency level, with only a small part of the voice channels available taken out of service for this purpose.

The levels of pilot voltages can also be measured in service in the same way along the route, and finally any other test signals sent, for instance, in gaps between channels. In the case of low levels selective measurements provide the advantage that noise does not affect the outcome; this fact can also be utilized at audio frequencies (without automatic tuning) down to 2000 c/s.

With S1 the meter can be set for the indication of power levels (0 dbm corresponding to 1 mw) into impedance values of 75, 135 or 140, and 600 Ω; for each of these values the input impedance can be made "high" or equal to Z.

For bridging leveling operate the impedance selector switch to the position "High" corresponding to the impedance value of the specimen; with terminating leveling or where the circuit is broken after the leveling point, operate the switch to the related position "Z". In the positions "600 Ω" the meter reading equals also the voltage level (0 db corresponding to 0.775 v).

a. Wideband level measurements

After correct setting of the impedance selector S1 connect the specimen via a shielded cord to the input "Level", operate switch S2 to "Level Wideband" and S3 to some value in the wideband range where the meter reads in the right-hand portion of its scale. The unknown power level is found by adding the setting of S3 and the reading on the meter scale (observing the algebraic sign).

The maximum measurable level is +32 dbm. At 600 Ω it corresponds to about 30 v. For measuring voltage levels (0 db corresponding to 0.775 v) use the 600-Ω positions of S1. If need arises, connect terminations other than 600 Ω directly to the specimen (operate S1 in such case to "600 Ω ▼ High Imp.").

With voltage measurements on circuits one side of which is grounded a reading error up to about ±0.5 db may appear in the measuring range +30 dbm at frequencies above 900 kc/s.

b. Selective level measurements

In particular with in-service measurements on systems see to it that switch S1 "Z/Ω" is in its proper position, before connecting the specimen to the input (see above), since subsequent switching of S1 may give rise to service trouble. Connect the specimen via a shielded cord to the input "Level", operate switch S2 to "Level Selective" and S3 to a selective range where a well readable deflection appears on the meter scale.

With measurements without automatic tuning set S4 to the same frequency band as the level oscillator and tune the variable capacitor K1 for maximum meter deflection.

Frequencies f_m above 600 kc/s are read on the upper scale of K1, below 600 kc/s on the lower one. The indicating lamp Lp2 or Lp3 shows the activated band. To allow during in-service measurements on carrier systems an easy check whether the meter is tuned to the correct frequency, it is recommended to interrupt the output of the level oscillator momentarily.

With automatic tuning the level meter need no longer be tuned by means of S4 and K1. Once the level oscillator is aligned (see Sec. IV.2, p.14) at the beginning of the measurements the selective level meter keeps automatically in tune in any setting of the level oscillator.

The measuring values are read and the measuring result established in the same way as with wideband level measurements (Sec. IV.3a, p.16).

4. Crosstalk attenuation measurements

In the same way as described under par.3b, carrier-frequency crosstalk of lines and connections is measured on selective basis. With measurements of near-end crosstalk connect the level oscillator to the near end, with measurements of far-end crosstalk to the far end of the disturbing line, while the selective level meter is invariably connected to the near end of the disturbed line via a shielded cord. Automatic tuning can thus be used with measurements of near-end crosstalk. Operate the impedance selector of the level oscillator to the impedance value of the dis-

turbing line (Z1) and that of the channel level meter so that of the disturbed line (Z2) (S1 hence thus to the corresponding position, input impedance = "Z"). Terminate the other (free) ends of the lines into individual resistors (Z1 or Z2).

Crosstalk attenuation equals the difference of transmitting level and the measured receiving power level. With a transmitting level of +17 db crosstalk attenuation up to 125 db can be measured.

5. Distortion attenuation measurements

Because of its high residual distortion attenuation which amounts to about 70 db with an input level < +30 db throughout the frequency range, the selective level meter is also suitable for finding the distortion attenuation of carrier generators and transmission facilities.

Terminate the specimen into its characteristic impedance and connect it with shielded cords between the jacks "Output" on the level oscillator and "Level" on the level meter. See to it that the connecting cord "Automatic Tuning" on the level meter is pulled.

Start by measuring the voltage level (S1 hence at "600 Ω▼, High Imp.") for the frequency f_o in the manner described. Subsequently tune in succession to the harmonics $f_2 = 2f_o$, $f_3 = 3f_o$, etc., with a corresponding stepup in sensitivity by means of S3. The difference of the harmonic and fundamental levels measured is the distortion attenuation of the respective harmonic. See to it that in shifting to measurements of the harmonic level the sensitivity of the device is not increased by more than five steps of switch S3. From the distortion attenuation a_k the distortion factor k can be calculated as a percentage using the following formula:

$$k = 100 \times 10^{a_k/20},$$

where a_k is expressed in decibel.

6. Impedance magnitude measurements (Fig. 5)

Impedance is measured on wideband basis as a rule. Selective measurements are recommended where noise or harmonics might introduce measuring errors. High noise can be anticipated above all in the case of large unshielded specimens such as open-wire lines. Harmonics will be most annoying in the case of impedances depending greatly on frequency.

With use of the automatic tuning system the selective measurement is just as simple as its wideband counterpart. Measurements at audio frequencies are possible on wideband basis only.

Connect the specimen to the jacks "X" and the level oscillator e.g. Type Rel 3 W 29s or s2 to the level oscillator jacks "G" via shielded cords; set the level oscillator for wideband measurements to a transmitting level of +17 db, for selective measurements to -10 db as well as to the measuring frequency, with a source impedance of approximately zero. On the level meter operate switch S1 to "High Impedance ▼ ", switch S2 to "Impedance Wideband" or "Selective", S3 to the range most favorable for readings (reading multiplier x1, x2, or x10). If with selective measurements the automatic tuning system is not employed tune the meter beforehand for maximum pointer deflection by means of S4 and the capacitor K1.

7. Balance-to-unbalance ratio measurements (Fig. 6)

For determining on a specimen such as a line, transformer, balanced filter, etc. the balance-to-unbalance ratio, i.e. the degree of balance of the specimen with respect to ground, connect the specimen to the jacks "X" and the level oscillator to the level oscillator jacks "G" via shielded cords, after setting it to the desired measuring frequency with a source impedance of approximately zero. Automatic tuning makes also this selective measurement as simple as its wideband equivalent. The considerations of par. 6 hold also in this case, as to whether preference is to be given to selective or wideband measurements.

Operate switch S1 to "High Imped.▼ ", S2 to "Balance Wideband" or "Balance Selective"; with selective measurements without automatic tuning adjust S4 and K1 for maximum meter deflection. The level is read on switch S3 and the panel meter.

The balance-to-unbalance ratio is the difference between the transmitting level and the reading on the level meter, less 17 db, so that with a transmitting level of +17 db the balance-to-unbalance ratio just equals the level meter reading, but with the algebraic sign reversed. It corresponds to the expression $20 \log_{10} \frac{W1+W2}{W1-W2}$ in decibel.

8. Return loss measurements (Fig. 7)

Return loss can always be measured when different components are to be interconnected to a transmission system, for instance, if line sections of different characteristic impedance are interconnected via impedance matching transformers. If one section of cable is connected to the jacks "X", and that to be matched is connected via a corresponding transformer to the jacks "Balancing Network", the return loss measured is representative of the mismatch or reflection coefficient:

$$\text{return loss in decibel} = 20 \log_{10} \frac{1}{\text{mismatch}} .$$

If the specimen is compared with a complex impedance connected to the terminals "Balancing Network" (e.g. series network of C and R) the value determined for maximum return loss (minimum meter deflection) of the complex impedance corresponds to the specimen impedance by magnitude and phase.

Also in this case the statements of Sec. 6 govern the decision as to the mode of measurement ("wideband" or "Selective").

Connect via shielded cords the line under test or specimen to the jacks "X", and the balancing network or comparison network to the jacks "Balancing Network", and the level oscillator, e.g. Type Rel 3 W 29s, to the jacks "G". Set the level oscillator to the desired measuring frequency and a transmitting level suitable for the specimen, with "Low" source impedance. The voltage levels across specimen Z and standard N are about 17 db lower than the level oscillator setting. Operate switch S1 to "High ▼ ", S2, depending on the measurement, to "Return Loss Wideband" or "Selective", and adjust S3 for a well readable meter deflection. In case of selective measurements without automatic tuning system adjust the capacitor K1 (S4) for maximum deflection. The return loss is the difference between transmitting level and level meter reading less 17 db. With a transmitting level of +17 db the return loss thus equals numerically the level meter reading.

Return loss depends strongly on frequency as a rule. In the case of mismatch maxima and minima make their appearance. The return loss stated is always the lowest value measured within a given range of frequency. The distance from the origin of the mismatch can be calculated from the separation of the maxima and minima by the method devised by Küpfmüller.

9. Sweep-frequency setup for selective measurements (Fig. 9)

a. Layout

Couple the sweep drive Type Rel 3 W 914a or b to the control "Frequency Control Coarse" of the level oscillator (as described in the brochure Rel beschr 3 W 914a,b En). With shielded cords, e.g. Type Rel ltg 546, connect the jacks "Hor.Defl.Ext." on the level tracing receiver Type Rel 3 K 29s to the jacks "Freq.Comp." on the level oscillator, and the jacks "Input A" to the output jacks "↑" on the level meter. Plug further the coaxial cord into level oscillator and level meter (for the automatic tuning system) Type Rel ltg 533. Turn on and adjust level oscillator and level meter according to their "Instructions for Use". Insert on the level tracing receiver the screen graticule corresponding to the sweep range chosen (II to V) and perform the calibrating procedures I, III, and IV as usual. Since the 0-db line must be set for the input level on the level meter or the ohm scale for the measuring circuit of the level meter, make the following alignments before the measurements:

b. Alignments for all measurements except those of impedance

Sweep the level oscillator as with the subsequent measurement.

Perform on the level meter all settings according to Sec.2.b "Cal.II" (p.14). On the level tracing receiver operate S1 to "Leveling", the impedance selector switch S2 to "High ▼", band switch S3 to "0.3 to 10 kc/s", range switch S7 to the sweep range selected on the level oscillator, e.g. "2 to 600 kc/s", function switch S4 to "0 db", switch S6 to "Normal" (the vertical spread using the screen graticule without numbers is not suitable for this measurement), switch S9 to "Hor.Defl.Ext.".

If during the measurements the impedance selector S1 on the level meter is shifted to some other value, the impedance switch S2 on the level tracing receiver is left at "High ▼" since the gain increment required with measurements of power levels at different impedance values may be introduced at a single point only.

After these settings the horizontal line on the screen of the level tracing receiver is shifted accurately to the 0-db line of the scale with the control P7 "▼II 0 db"; S1 will remain as a rule on the 0-db mark in this procedure. If the setting range of P7 should not suffice,

[illegible] may also be used for this adjustment. For checking the calibrated reading switch S1 to the level meter frequently from the output "A" to the meter "E". The level meter reading must agree with that on the level meter.

If the level oscillator output is connected direct to the receiver input, the calibration of all devices may be checked as stated in the last paragraph of Sec.IV.3 (p.[illegible]).

5. Alignment for impedance measurements

In addition to the connections mentioned at the beginning of Sec.IV.5 connect the output of the level oscillator to the jacks "3" of the level meter via a shielded cord. Connect to the level meter jacks "4" a resistor [illegible] the order of the reciprocal of the expected, for level oscillator and level meter for selective impedance measurements, as shown in Sec.IV.4 (p.[illegible]). Transfer now to the level meter switch S1 from the output "A" to the meter "E".

On the level tracking receiver all switches remain in the positions stated in Sec.IV.5a. With S2 "[illegible] 2 Hz" and possibly in addition with S3 set on the IBM screen the known impedance value or that read on the level meter [illegible] the position "E" of S1.

6. Measuring

After this alignment have the [illegible] receiver undisturbed, [illegible] all the range switch S5, i.e. make all alignments for the measurements (5.) on the level meter, as described under Sec.IV 3 to 5. The screen of the level tracking receiver will now display the quantity under test as a linear trace in function of frequency. The unknown level is found by setting the value set on S1 of the level meter and the reading on the [illegible] graticule of the level tracking receiver. The impedance measured has the reading in the screen graticule must be multiplied by the factor set on the level meter S2 at "Impedance Selective x", x2, or x1/2. Individual values of special interest may also be read out more accurately on the panel instrument of the level meter by switch switch S3. For this purpose turn off the sweep drive and adjust the oscillator frequency by hand, as used above.

V. HINTS ON MAINTENANCE

As a rule malfunction of the set will be evident by the fact that the red mark can no longer be set in the calibrating procedure.

If only the procedure "Cal.II" can no longer be effected, the wideband level meter circuit and calibrating generator are obviously in order and the fault must be looked for in the heterodyning converter.

If with selective measurements the device performs properly only with automatic tuning, the fault is due to the oscillator unit G'.

If the red mark can no longer be attained in any calibrating position, make preferably a check in the settings "Channel Level" and "Wideband Level" with a known voltage applied to the input terminals, whether the nominal deflection can be brought about with the controls (P', P2'). If this is possible, the fault is due to the calibrating generator.

Faults, if any, will be due to worn or defective tubes as a rule. By checking the tubes of the affected subassembly in a tube tester the worn tube is located and replaced.

For removing the chassis, loosen the eight fastening screws with the front panel held horizontal; subsequently restore the set to its normal position and withdraw the chassis from the casing. The output of the three generator units G1, G2, G3 can be checked at the connecting points of the subassembly with an RF voltmeter, e.g. RF Multitest meter. The output of G1 at "i, k" is 2.5 v ±10 %; that of G2 at "am, ao" 0.3 v ±10 %, that of G3 at "am, al" 150 mv corresponding to -14 db.

Excessive output of the oscillator unit G3 or fixed-frequency oscillator unit (G2) may be due to burnout of a regulating lamp, if the tubes are in order. Because of low filament temperature and particularly careful manufacture these special lamps have indeed many years of useful life, but they may be destroyed, for instance, by heavy mechanical shock. After the insertion of spare lamps (Type Rel 678 A 4), only the voltage of the calibrating generator needs readjustment; for this purpose there is applied to the input a reference voltage of 5 kc/s with zero source impedance, that accurately corresponds to the voltage level 0 db. Preferably this voltage is set by reference to a calibrating level meter, e.g. Type Rel 9 2 512 (for details see Rel Report 9 2 512 BA). On the level meter operate switch S1 to "High ▼", S2 to "Wideband Level" and

S3 to "Wideband 0 db" and bring the pointer to the red mark with the potentiometer P1. Subsequently switch S2 to "▼ I" and, without changing the setting of P1, adjust with R7 (accessible at the side of the oscillator subassembly Type Rel 35 D 360 according to Fig.2) the output voltage of the calibrating generator in a way that the meter deflection regains the red mark.

All switches and other mechanical control elements will require no special maintenance effort for a long time. During transportation the vacuum and stabilizer tubes may be left seated. Lay the power cord around the pulling handles and insert the mains plug into the dummy jacks.

With an input voltage of exactly 220 v the set shall not draw more than 450 ma, and with the other mains voltages 110, 130, 200, or 240 v it shall remain below the corresponding value. With mains voltage variations up to ±4 % the following operational voltages will result:

a. AC voltages (measured, for instance, with Multizet meter 1000 Ω/v)

Heater voltages
of the tubes 1a to 9 . . . . . 6 to 6.6 v

Heater voltages
of the tubes 10, 11, 12 . . . . . 19 to 21 v

AC voltage
across anode winding of power transformer
(measured between 7c and 8c) . . . . . approx. 250 to 260 v

b. DC voltages (measured with voltmeter 50,000 Ω/v, e.g. Siemens-µa-Multizet meter; guiding values in volts)

Tube	1a	1b	4	5	6	7	8	9	10	11	12
E_b	135	160	100	200	125	90	140	110	170	200	200
E_{c2}			100	160	100	120	125	150	200	130	125
E_k	13 ± 0.5 [2]	12.5 [2]	1.6	2.2	2	2	2	2.3	1.8	4	4.2

[1] Voltage at B2

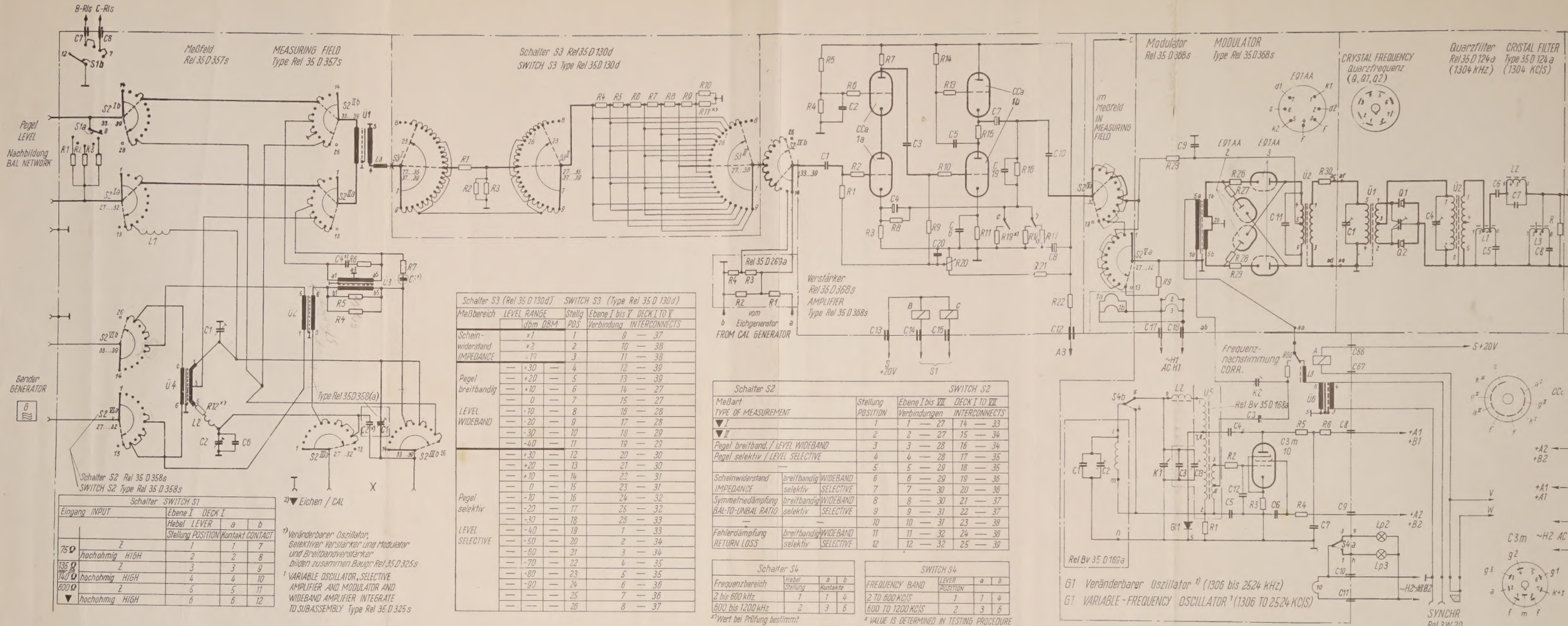
[2] Voltage at K1

VI. ACCESSORIES, DIMENSIONS, AND WEIGHTS

Description	Type	Dimensions in ft./in. (mm)	Approx. weight in lb (kgs)
Level meter -100 to +30 dbm			
(0.3 to 1200 kc/s)	Rel 3 D 332s or s2	1'9 5/8" x1'2 1/2"x11" (550x368x280)	77 (35)
Accessories			
2 tubes	CCa	-	-
6 tubes	C3g	-	-
3 tubes	C3m	-	-
2 double diodes	E91AA	-	-
2 stabilizer diodes	STV 100/60 Z II	-	-
1 indicating lamp 6 v . . .	9 T 1p 2b	-	-
2 indicating lamps 24 v . .	Fg 1p 62a	-	-
3 fuses 1 a (2 as spares)	1 C DIN 41571	-	-
Optional			
1 source of measuring power, e.g. level oscillator (0.3 to 1200 kc/s)	Rel 3 W 29s or s2	1'9 5/8"x1'2 1/2"x11" (550x368x280)	66 (30)
2 balanced connecting cords, e.g.	Rel ltg 546a-d	1'8" to 6'7" (500 to 2000)	0.44 (0.2)
or	Rel ltg 703b-e	1'8" to 6'7" (500 to 2000)	0.44 (0.2)
1 coaxial connecting cord, e.g.	Rel ltg 533b-f	1'8" to 6'7" (500 to 2000)	1.65 (0.75)
1 earphone, e.g.	9 Fg tph 2a	-	-
1 level tracing receiver (0.3 to 1200 kc/s)	Rel 3 K 29s	1'9 5/8"x1'2 1/2"x1'1 3/8" (550x368x340)	77 (35)

Description	Type	Dimensions in ft./in. (mm)	Aprox. weight in lb (kgs)
1 sweep drive	Rel 3 W 914a,b	$7^{3}/4$"x$10^{7}/8$"x$7^{1}/8$" (198x275x180)	11 (5)
1 decade resistor (up to 500 kc/s)	Rel 3 B 41	$5^{3}/8$"x$10^{1}/2$"x$7^{1}/8$" (137x266x180)	3.3 (1.5)
and			
1 decade capacitor (up to 500 kc/s)	Rel 3 B 51	$5^{3}/8$"x$10^{1}/2$"x$7^{1}/8$" (137x266x180)	3.3 (1.5)
or			
variable balancing network	Rel 3 L 311c	1'$9^{5}/8$"x1'$2^{1}/2$"x11" (550x368x280)	62 (28)
or			
balancing network synthesizer	Rel 3 L 21a	1'$10^{1}/4$"x1'$4^{1}/2$"x$5^{7}/8$" (565x420x150)	28.6 (13)

inted in Germany


B-Ris C-Ris
Meßfeld Rel 35 D 357s
MEASURING FIELD Type Rel 35 D 357s
Schalter S3 Rel 35 D 130d
SWITCH S3 Type Rel 35 D 130d
Pegel LEVEL
Nachbildung BAL NETWORK
Rel 35 D 269a
Verstärker Rel 35 D 368s AMPLIFIER Type Rel 35 D 368s
vom Eichgenerator FROM CAL GENERATOR
Modulator Rel 35 D 368s
MODULATOR Type 35 D 368s
im Meßfeld IN MEASURING FIELD
CRYSTAL FREQUENCY Quarzfrequenz (Q, Q1, Q2)
Quarzfilter Rel 35 D 124a (1304 kHz)
CRYSTAL FILTER Type 35 D 124a (1304 KC/S)
Sender GENERATOR
Type Rel 35 D 358(a)
Schalter S2 Rel 35 D 358s
SWITCH S2 Type Rel 35 D 358s
Frequenz-nachstimmung CORR.
Rel Bv 35 D 168a
Rel Bv 35 D 169a
SYNCHR Rel 3 W 29
G1 Veränderbarer Oszillator 1) (1306 bis 2524 kHz)
G1 VARIABLE-FREQUENCY OSCILLATOR 1) (1306 TO 2524 KC/S)
2) ▼ Eichen / CAL
X

Schalter S3 (Rel 35 D 130d)				SWITCH S3 (Type Rel 35 D 130d)		
Meßbereich	LEVEL RANGE			Stellg	Ebene I bis V	DECK I TO V
		dbm	DBM	POS	Verbindung	INTERCONNECTS
Schein-widerstand IMPEDANCE		×1		1	9 —	37
		×2		2	10 —	38
		×10		3	11 —	38
Pegel breitbandig LEVEL WIDEBAND	—	+30	—	4	12 —	39
	—	+20	—	5	13 —	39
	—	+10	—	6	14 —	27
	—	0	—	7	15 —	27
	—	-10	—	8	16 —	28
	—	-20	—	9	17 —	28
	—	-30	—	10	18 —	29
	—	-40	—	11	19 —	29
Pegel selektiv LEVEL SELECTIVE	—	+30	—	12	20 —	30
	—	+20	—	13	21 —	30
	—	+10	—	14	22 —	31
	—	0	—	15	23 —	31
	—	-10	—	16	24 —	32
	—	-20	—	17	25 —	32
	—	-30	—	18	26 —	33
	—	-40	—	19	1 —	33
	—	-50	—	20	2 —	34
	—	-60	—	21	3 —	34
	—	-70	—	22	4 —	35
	—	-80	—	23	5 —	35
	—	-90	—	24	6 —	36
	—	—	—	25	7 —	36
	—	—	—	26	8 —	37

Schalter S2			Stellung POSITION	SWITCH S2 Ebene I bis VII Verbindungen	SWITCH S2 DECK I TO VII INTERCONNECTS
Meßart TYPE OF MEASUREMENT					
▼ I			1	1 — 27	14 — 33
▼ II			2	2 — 27	15 — 34
Pegel breitband. / LEVEL WIDEBAND			3	3 — 28	16 — 34
Pegel selektiv / LEVEL SELECTIVE			4	4 — 28	17 — 35
—			5	5 — 29	18 — 35
Scheinwiderstand IMPEDANCE	breitbandig	WIDEBAND	6	6 — 29	19 — 36
	selektiv	SELECTIVE	7	7 — 30	20 — 36
Symmetriedämpfung BAL-TO-UNBAL RATIO	breitbandig	WIDEBAND	8	8 — 30	21 — 37
	selektiv	SELECTIVE	9	9 — 31	22 — 37
—	—		10	10 — 31	23 — 38
Fehlerdämpfung RETURN LOSS	breitbandig	WIDEBAND	11	11 — 32	24 — 38
	selektiv	SELECTIVE	12	12 — 32	25 — 39

Schalter S1					
Eingang INPUT		Ebene I DECK I			
		Hebel LEVER	a	b	
		Stellung POSITION	Kontakt CONTACT		
75 Ω	Z	1	1	7	
	hochohmig HIGH	2	2	8	
135 Ω 150 Ω 110 Ω	Z	3	3	9	
	hochohmig HIGH	4	4	10	
600 Ω	Z	5	5	11	
▼	hochohmig HIGH	6	6	12	

Schalter S4			
Frequenzbereich	Hebel Stellung	a Kontakte	b
2 bis 600 kHz	1	1	4
600 bis 1200 kHz	2	3	6

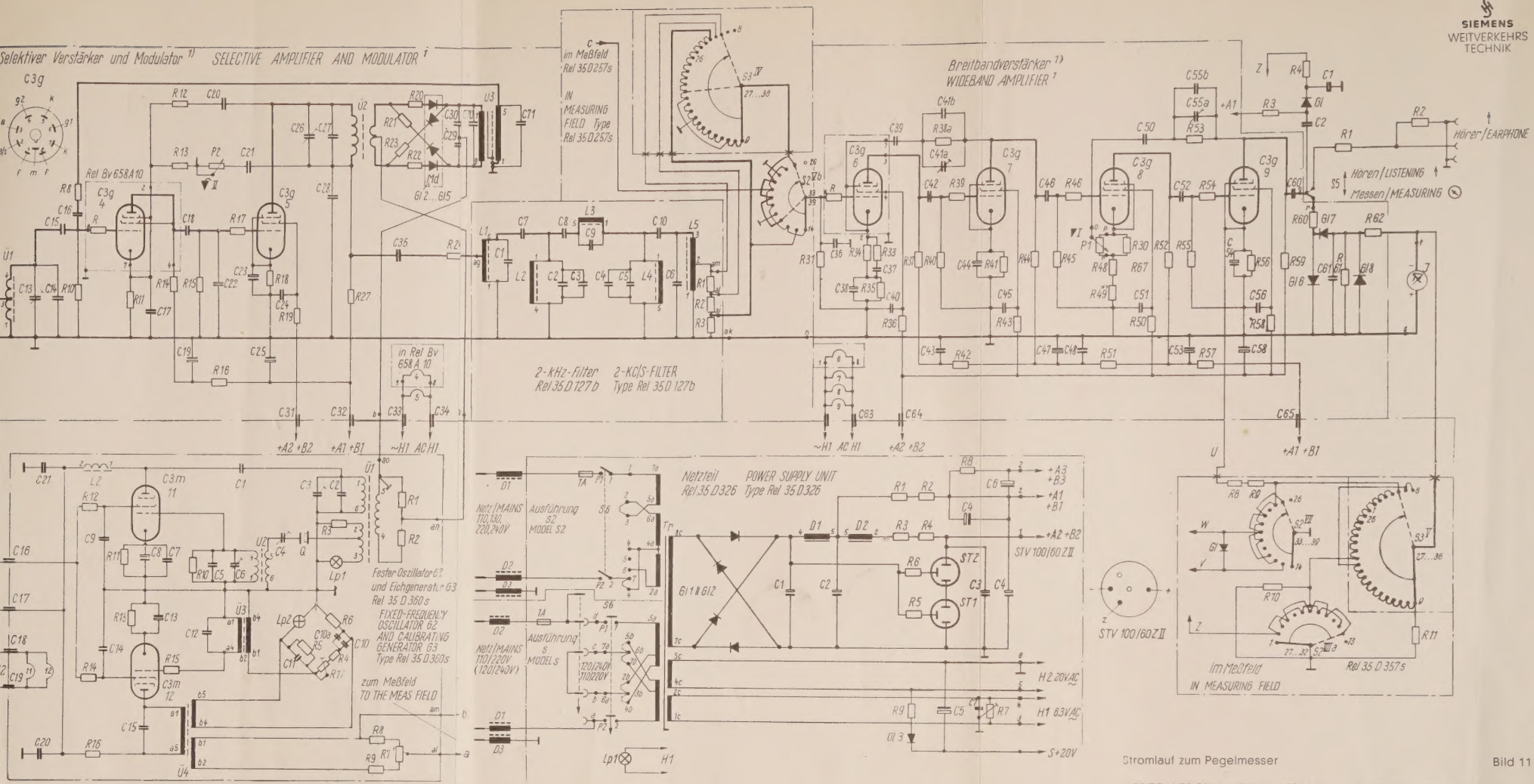
x) Wert bei Prüfung bestimmt

SWITCH S4			
FREQUENCY BAND	LEVER POSITION	a	b
2 TO 600 KC/S	1	1	4
600 TO 1200 KC/S	2	3	6

x VALUE IS DETERMINED IN TESTING PROCEDURE

1) Veränderbarer Oszillator, Selektiver Verstärker und Modulator und Breitbandverstärker bilden zusammen Baugr. Rel 35 D 325s

1 VARIABLE OSCILLATOR, SELECTIVE AMPLIFIER AND MODULATOR AND WIDEBAND AMPLIFIER INTEGRATE TO SUBASSEMBLY Type Rel 35 D 325s


Selektiver Verstärker und Modulator 1)
SELECTIVE AMPLIFIER AND MODULATOR 1
Breitbandverstärker 1)
WIDEBAND AMPLIFIER 1
Rel Bv 658A10
in Rel Bv 658 A 10
2-KHz-Filter Rel 35 D 127 b
2-KC/S-FILTER Type Rel 35 D 127b
Netzteil Rel 35 D 326
POWER SUPPLY UNIT Type Rel 35 D 326
Netz/MAINS 110,130, 220,240V
Ausführung S2 MODEL S2
Ausführung S MODEL S
Netz/MAINS 110/220V (120/240V)
120/240V 110/220V
Fester Oszillator 62 und Eichgenerator 63 Rel 35 D 360 s
FIXED-FREQUENCY OSCILLATOR 62 AND CALIBRATING GENERATOR 63 Type Rel 35 D 360s
zum Meßfeld TO THE MEAS FIELD
im Meßfeld IN MEASURING FIELD Rel 35 D 357 s
STV 100/60 Z II
Hören/LISTENING
Messen/MEASURING
Hörer/EARPHONE
+A2 +B2
+A1 +B1
~H1 AC H1
H2 20V AC
H1 6.3V AC
S+20V

Stromlauf zum Pegelmesser — Bild 11

-100 TO +30 DBM 0,3 TO 1200 kHz Type Rel 3 D 332s(2)

CIRCUIT DIAGRAM OF THE LEVEL METER — Fig. 11

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